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ENGINE PERFORMANCE EVALUATION OF WCOME/AONP BIODIESEL BLENDS USING TAGUCHI ANALYSIS

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ABSTRACT

Plant based biofuels, either directly or indirectly produced, are a well researched area in the replacement of fossil fuels. These are mainly chosen due to the nature and availability of the main ingredients for biofuels production. The objective of this research work is to study the performance of Waste cooking oil methyl ester (WCOME) with Aluminium Oxide Nanoparticles (AONP) in a diesel engine. The experiments were designed using the Taguchi technique. The Waste Cooking Oil was transesterified using Methanol and Sodium Hydroxide as a catalyst. The performance and results are obtained using the Taguchi technique to optimize the parameters under consideration. The statistical analysis of the results indicates the optimum value of the engine performance parameter is 50% load, 20% biodiesel, 25ppm nanoparticles and 200Bar of injection pressure.

KEYWORDS: Biodiesel, Taguchi, WCO, AONP.

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Original Article

INTRODUCTION

Petroleum products or fossil fuels have always been in high demand due to their high energy density and ease of use. But due to the increase in energy demand and decrease in the availability of these fuels, alternatives are always sought after. One such alternative is the biodiesel derived from the waste of plants and animals. The major demand for fuel is from the transport sector and hence a product with similar energy density and lower production cost is necessary. In India, the advancement of non-edible vegetable oils as feedstock for Biodiesel creation utilizing Jatropha and Pongamia were considered as choices. The high cost of production and low yields make non-edible oils a poor substitute for diesel and hence the use of waste cooking oil was studied. The increase in the availability of waste cooking oil from restaurants and fast food corners make a great source for transesterification into biodiesel.

Hossain et al., [1] worked on the comparison of used and fresh sunflower oil as a source for biodiesel production. The engine performance of transesterified waste and fresh cooking oil was studied. Darwin et al., [2] studied the use of ultrasound as an accelerant for the production of biodiesel by way of transesterification of waste cooking oil and concluded that a 20kHz ultrasound induction may improve the rate of biodiesel production. Jehad A Yamin et al., [3] announced the properties of biodiesel derived from fresh and waste cooking oil in comparison with diesel with the thermal efficiency, power, and force of WCOME improved while there was a decline in specific fuel consumption. Karthik N et al., [4] explored different avenues regarding 20% of mixed rubber seed oil with different injection timing and uncovered 30° injection timing gave a better outcome. Senthil Kumar [5]

recorded a decrease in emissions and an improvement in execution while involving waste cooking oil emulsion in a pressure start motor with practically no adjustment, when contrasted and slick waste cooking oil.

Nantha Gopal et al., [6] point by point that the waste cooking oil had similar qualities like diesel and saw a decline in CO, HC, smoke, brake warm capability and development in NOx and express fuel use with blends of Waste cooking Oil and diesel. Siva R et al., [7] Taguchi dim social upgrade has been achieved for palm oil blended biodiesel to diminish the NOx outpouring. Makame Mbarawa [8] found that usage of half diesel - clove stem oil blends incited higher brake warm efficiency, brake express fuel use, and NOx and reduction in HC release differentiated and diesel. Hu seyin Aydin [9] investigated the show of the cottonseed methyl esters as fuel in a Diesel engine and saw that the extension in the blends of cotton seed methyl esters in with diesel diminished the vapor surge with basically no change in the engine. Jagannath Hirkude [10] explored the usage of waste cooking oil as fuel in assessment with mineral diesel, by changing the tension extent, weight, and blend at a predictable speed of 1500 rpm and itemized that there was a reduction in CO and particulate matter in B0, B50, and B70, and an extension in NOx and vapor gas temperature. T.F. Yusaf et al., [11] uncovered that blending crude palm oil and normal diesel in various degrees and preheating up to 60°C could reduce consistency and when injected in the engine at different rpm, it incited higher power and higher power yield other than an extension in BSFC. Moreover, a reduction in NOx and a development in CO spreads was taken note of.

EXPERIMENTAL PROCEDURE

All the experiments were done at a speed of 1400 rpm maintained at 23° BTDC (before top dead centre) for blended fuel. The experiments were conducted using B10 (10% WCOME, 100% diesel), B20 (20% WCOME, 80% diesel), B30 (30% WCOME, 70% diesel), B40 (40% WCOME, 60% diesel) for different load conditions on the engine and the results are presented in Table 3. The Injection Pressure was varied (160, 180, 200 and 220 bar). The fuel was replaced and the fuel lines were cleaned and the engine was left to operate for 30 min to stabilize after every experiment. Figure 1 shows the whole engine assembly used for the experiment. The engine exhaust (CO, HC, CO2, O2, and NOx) was analyzed and calculated by AVL DIG AS 444 gas analyzer fitted with DIGAS SAMPLER at the exhaust. The orthogonal array selected for the present research work is given below.

Table 1: Assignment of the Levels for L16 Orthogonal Array for Engine Performance Study

PARAMETERS	UNIT	NOTATION	LIMITS			
			Level 1	Level 2	Level 3	Level 4
Load (A)	%	L	25%	50%	75%	100%
Bio-diesel (B)	%	WCOME	B10	B20	B30	B40
Nanoparticles (C)	Ppm	AONP	0	25	50	75
Injection Pressure (D)	Bar	IP	160	180	200	220

Table 2: Design of Matrix for Engine Performance of WCOME/Al2O3 Biodiesel Using L16 Orthogonal Array

Exp no.	Design of matrix				Load (A)	Bio-diesel (B)	Nanoparticles (C)	Injection Pressure (D)
	A	B	C	D				
1	1	1	1	1	25%	B10	0	160
2	1	2	2	2	25%	B20	25	180
3	1	3	3	3	25%	B30	50	200
4	1	4	4	4	25%	B40	75	220
5	2	1	2	3	50%	B10	25	200
6	2	2	1	4	50%	B20	0	220
7	2	3	4	1	50%	B30	75	160
8	2	4	3	2	50%	B40	50	180
9	3	1	3	4	75%	B10	50	220
10	3	2	4	3	75%	B20	75	200
11	3	3	1	2	75%	B30	0	180
12	3	4	2	1	75%	B40	25	160
13	4	1	4	2	100%	B10	75	180
14	4	2	3	1	100%	B20	50	160
15	4	3	2	4	100%	B30	25	220
16	4	4	1	3	100%	B40	0	200

RESULTS AND DISCUSSIONS

Table 3: Results of Engine Performance of Diesel and WCOME Biodiesel Blends

Expt. No	BP kW	BSFC kg/kW-h	BTE	EGT C
1	0.965	0.762	12.574	277.228
2	0.995	0.785	12.955	285.628
3	1.025	0.809	13.348	294.283
4	1.056	0.834	13.752	303.200
5	1.950	0.500	17.798	369.964
6	1.950	0.500	17.800	370.000
7	1.970	0.505	17.978	373.700
8	1.989	0.510	18.158	377.437
9	1.970	0.505	17.981	373.773
10	3.013	0.597	16.274	669.500
11	2.925	0.580	15.800	650.000
12	2.954	0.586	15.958	656.500
13	3.998	0.666	14.557	707.354
14	3.959	0.660	14.413	700.350
15	4.077	0.680	14.845	721.361
16	4.037	0.673	14.698	714.218

Table 4: S/N Ratio Results for Biodiesel Variables

Level	Load	Bio-Diesel	Nano particles	Injection Pressure
1	-39.42	-42.29	-43.49	-43.49
2	-41.57	-43.57	-43.59	-43.57
3	-45.21	-43.66	-42.44	-43.68
4	-47.06	-43.74	-43.74	-42.52
Delta	7.64	1.46	1.31	1.15
Rank	1	2	3	4

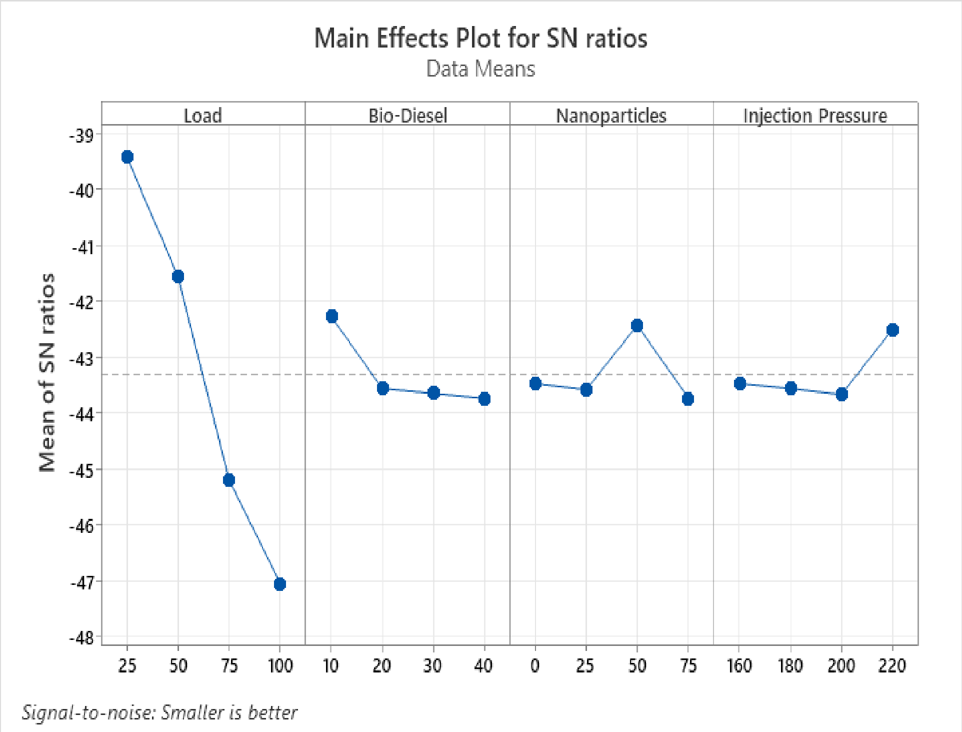

Figure 1: Main Effects Plot for S/N Ratio of Performance Parameters

GENERAL ANALYSIS OF VARIANCE

Table 5: Contribution Table for the Effect of Parameters on Brake Power for Engine Performance of WCOME/Diesel Blends under L16 Orthogonal Array

Source	DF	Adj SS	Adj MS	F-Value	P-Value	
Load (A)	3	19.3393	6.44644	104.9	0.002	0.135%
BioDiesel (B)	3	0.2286	0.07621	1.24	0.432	29.150%
Nanoparticles (C)	3	0.1986	0.0662	1.08	0.476	32.119%
Injection Pressure (D)	3	0.147	0.04901	0.8	0.572	38.596%
Error	3	0.1844	0.06145			
Total	15	20.0979				

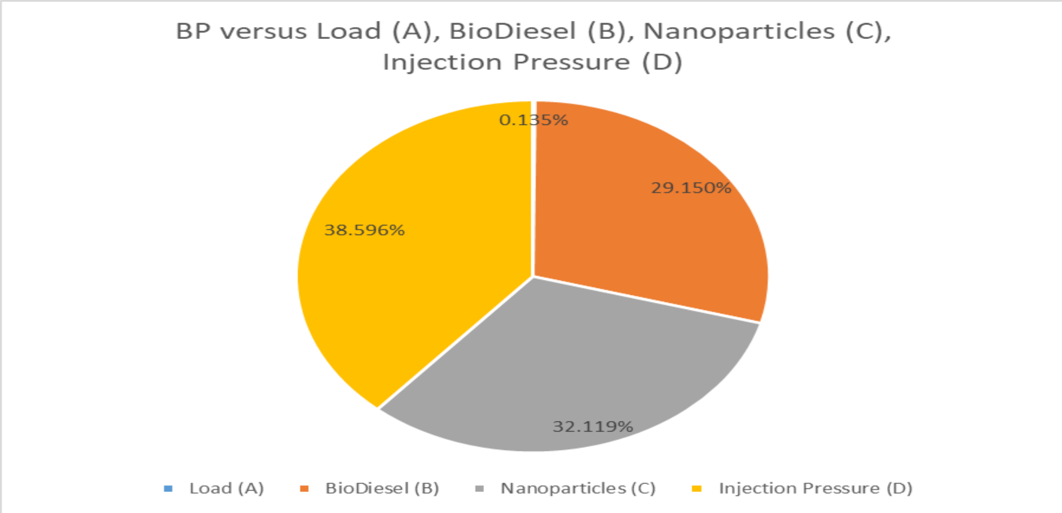

Figure 2: Contribution Chart for the Effect of Parameters on Brake Power for Engine Performance of WCOME/Diesel Blends under L16 Orthogonal Array

The analysis results indicate that the highest contribution on brake power is from % of biodiesel at 37.208% with nanoparticles and injection pressure following with 33.068% and 29.618% respectively. The change in load has very little effect on the performance parameters and can be neglected.

Table 6: Contribution Table for the Effect of Parameters on Brake Specific Fuel Consumption for Engine Performance of WCOME/Diesel Blends under L16 Orthogonal Array

Source	DF	Adj SS	Adj MS	F-Value	P-Value	
Load (A)	3	0.198078	0.066026	116.79	0.001	0.068%
BioDiesel (B)	3	0.004081	0.00136	2.41	0.245	16.712%
Nanoparticles (C)	3	0.001937	0.000646	1.14	0.458	31.241%
Injection Pressure (D)	3	0.000686	0.000229	0.4	0.762	51.978%
Error	3	0.001696	0.000565			
Total	15	0.206478				

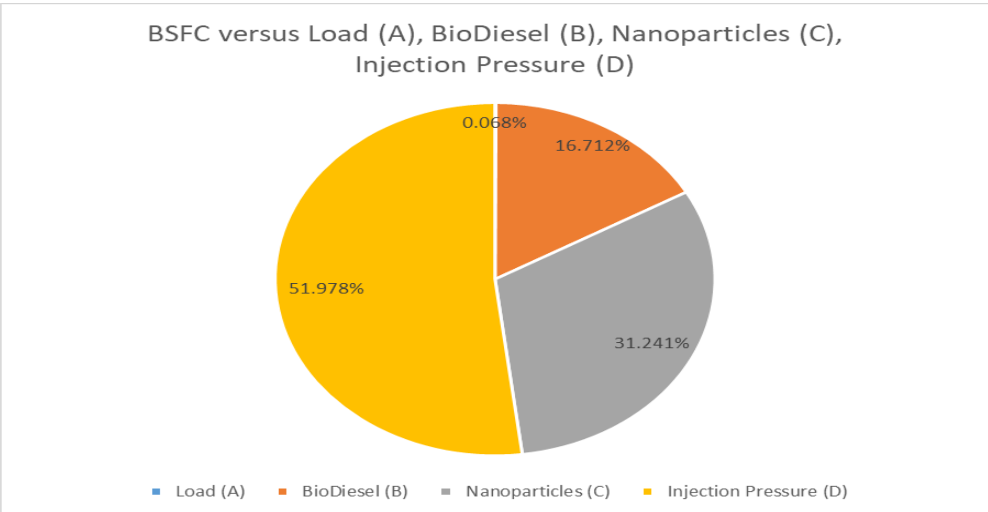

Figure 3: Contribution Chart for the Effect of parameters on Brake Specific Fuel Consumption for Engine performance of WCOME/Diesel Blends under L16 Orthogonal Array

The analysis results indicate that the highest contribution on brake specific fuel consumption is from injection pressure at 44.061% with nanoparticles and Biodiesel percentage following with 34.055% and 21.767% respectively. The change in load has very little effect on the performance parameters and can be neglected.

Table 7: Contribution Table for the Effect of Parameters on Brake Thermal Efficiency for Engine Performance of WCOME/Diesel Blends under L16 Orthogonal Array

Source	DF	Adj SS	Adj MS	F-Value	P-Value	
Load (A)	3	52.6544	17.5515	81.15	0.002	0.163%
BioDiesel (B)	3	0.3161	0.1054	0.49	0.715	58.130%
Nanoparticles (C)	3	1.2986	0.4329	2	0.292	23.740%
Injection Pressure (D)	3	1.729	0.5763	2.66	0.221	17.967%
Error	3	0.6488	0.2163			
Total	15	56.6469				

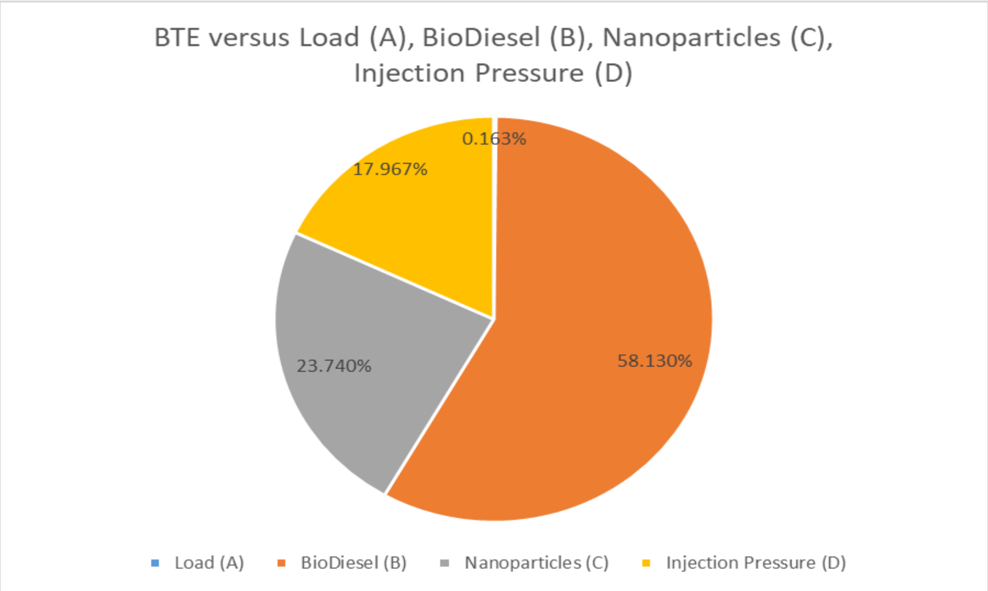

Figure 4: Contribution Chart for the Effect of Parameters on Brake Thermal Efficiency for Engine Performance of WCOME/Diesel Blends under L16 Orthogonal Array

The analysis results indicate that the highest contribution on brake thermal efficiency is from biodiesel percentage at 54.758% with nanoparticles and injection pressure following with 27.379% and 17.618% respectively. The change in load has very little effect on the performance parameters and can be neglected.

Table 8: Contribution Table for the Effect of Parameters on Exhaust Gas Temperature for Engine Performance of WCOME/Diesel Blends under L16 Orthogonal Array

Source	DF	Adj SS	Adj MS	F-Value	P-Value	
Load (A)	3	447858	149286	29.26	0.01	0.662%
BioDiesel (B)	3	18150	6050	1.19	0.446	29.536%
Nanoparticles (C)	3	15673	5224	1.02	0.492	32.583%
Injection Pressure (D)	3	12601	4200	0.82	0.562	37.219%
Error	3	15305	5102			
Total	15	509586				

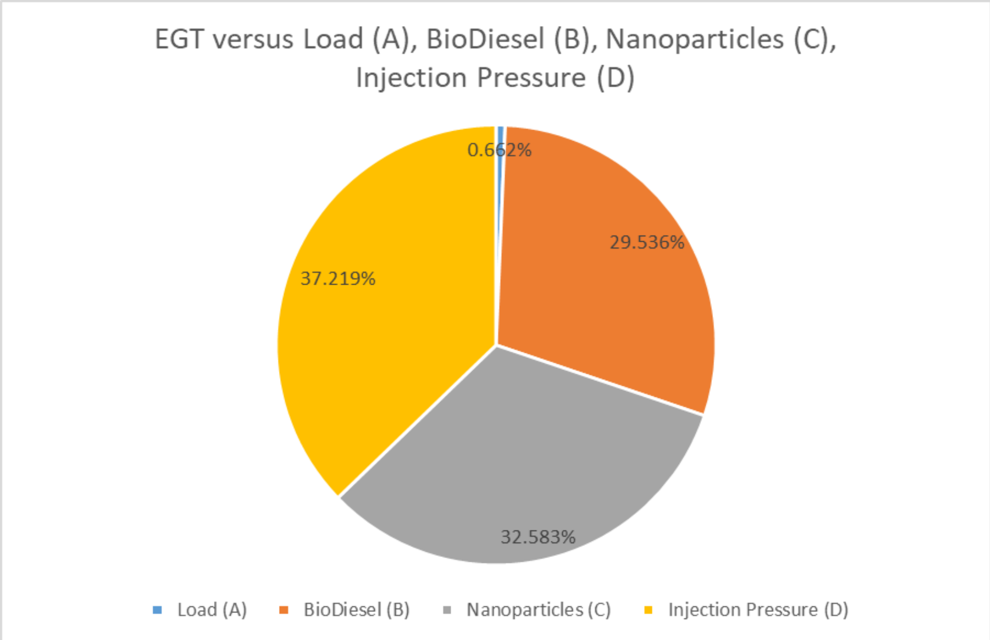

Figure 5: Contribution Chart for the Effect of Parameters on Exhaust Gas Temperature for Engine Performance of WCOME/Diesel Blends under L16 Orthogonal Array

The analysis results indicate that the highest contribution on exhaust gas temperature is from biodiesel percentage at 36.641% with nanoparticles and injection pressure following with 33.54% and 29.044% respectively. The change in load has very little effect on the performance parameters and can be neglected.

CONCLUSIONS

The work was initiated by an extensive literature survey which identified the shortcomings of the present research done on the selected non-edible oils. The research review helped in selecting the non-edible oil and the nano additives for biodiesel production and characterization. The properties of the methyl esters of these samples were compared with diesel to understand their suitability. The test results noted were Brake Power, Brake Specific Fuel Consumption, brake thermal Efficiency and Exhaust gas Temperature. The results, under the given conditions, show that the individual parameter analysis of the engine performance parameters gives a single point of optimum value. Considering all the parameters and analyses, the optimum value of the engine performance parameter is 50% load, 20% biodiesel, 25ppm nanoparticles and 200Bar of injection pressure.

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